Electron Beam Polarimetry: Update

2-11-2016

From last time...

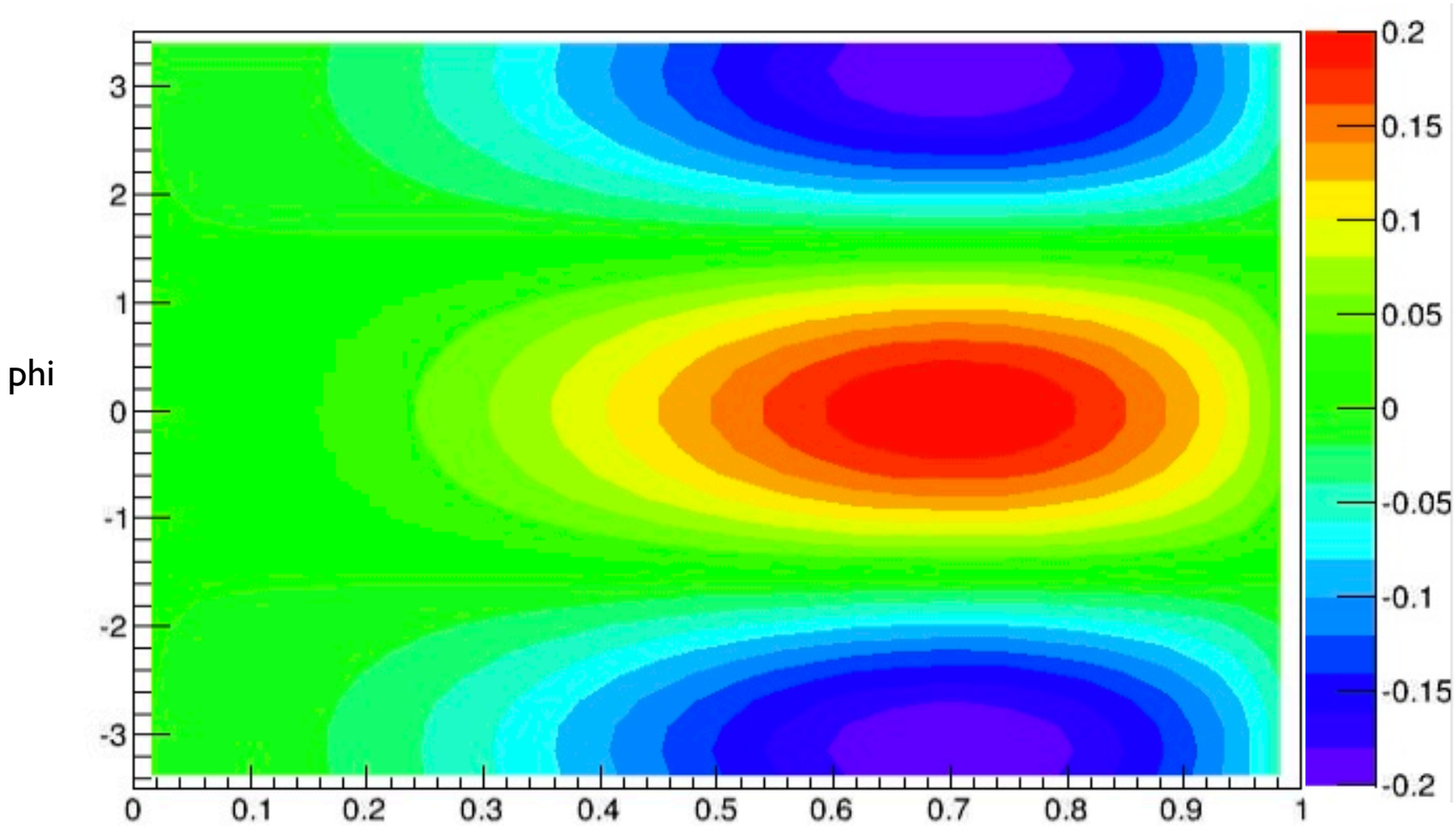
- was working on implementing a setup like the TPOL at HERA in the simulation
  - involved a segmented calo (up and down)
  - HERA electrons were transversely (vertical) polarized, leading to up/down asymmetry
  - this was a starting point, already knew this needed to be improved, but did not fully realize its shortcomings
- at the EIC R&D review practice talk
  - learned that I had sort of the wrong idea about what is needed to be measured
  - did not realize the differences between eRHIC and HERA
  - led to incorrectly assuming that at an eRHIC TPOL, we would only need an up/down asymmetry
  - actually can have both a vertical and/or horizontal transverse component (depends on how the beam goes through the spin rotators)
  - means measuring the full phi angle of the photon is more useful
  - current efforts focused on this front

Current Efforts

- develop fitting procedure to extract the polarization fraction and the polarization angle within a single fit
- fit the energy vs phi distribution as the cross section/asymmetries from QED are known in this space
- currently focused on extracting this from a purely transversely polarized beam
- will soon test on purely longitudinal and angles in between once current fits are stable
- using events generated from my toy MC Compton generator
- currently focused on using pure MC information (the true photon energy and phi angle)
- in parallel, developing a clustering algorithm to do this will real clusters
- will form some requirements on the calorimeter segmentation needed

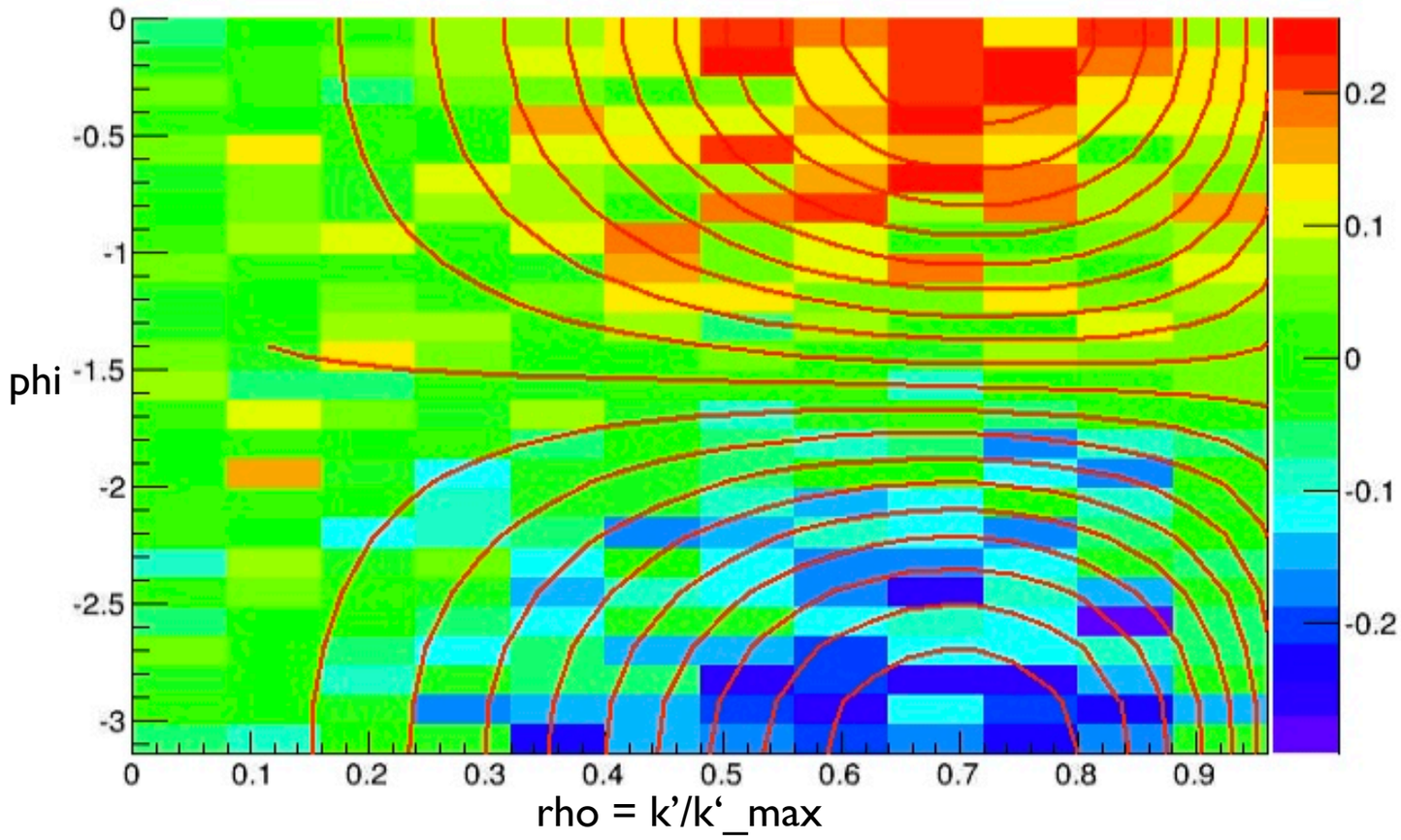
Reminder of asymmetry distributions

- pure transverse beam asymmetry in 2D
- 80% fraction
- 20 GeV x 2.33 eV



Fit to the generated distribution (transverse)

- represents roughly 60,000 x2 events
- generated from the distribution on the previous slide
- reminder: utilizing true MC information



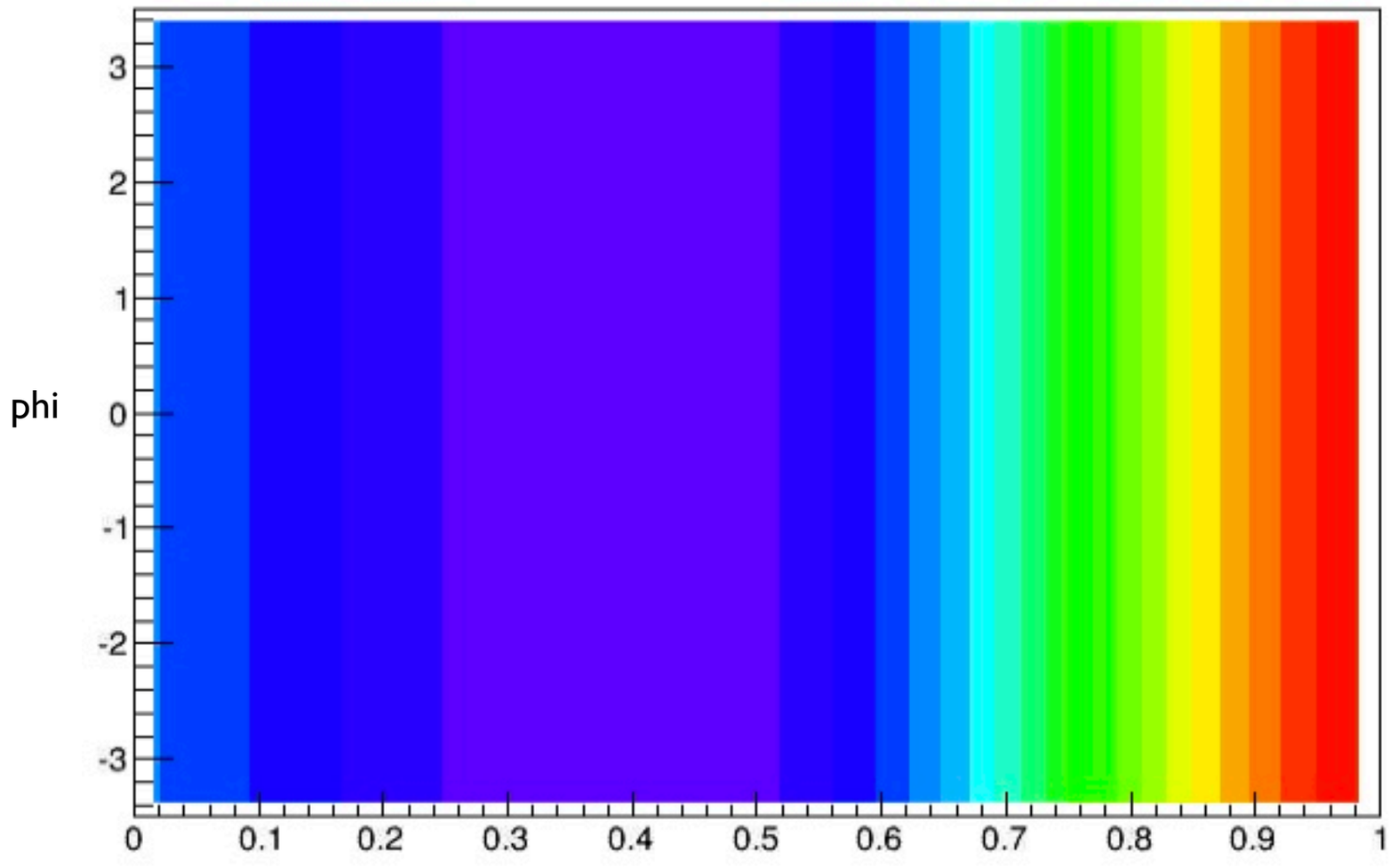
fit parameters:

pretty close to the input!

```
FCN=278.467 FROM MIGRAD    STATUS=CONVERGED      33 CALLS          34 TOTAL
                     EDM=1.33287e-10    STRATEGY= 1      ERROR MATRIX ACCURATE
 EXT PARAMETER                                   STEP         FIRST
 NO.   NAME      VALUE            ERROR          SIZE      DERIVATIVE
  1  p0           2.00000e+01     fixed
  2  p1           2.33000e-09     fixed
  3  p2           8.24730e-01   2.83508e-02   2.31348e-04   5.72499e-04
  4  p3           1.54994e+00   1.97072e-02   1.60816e-04  -1.12766e-04
```

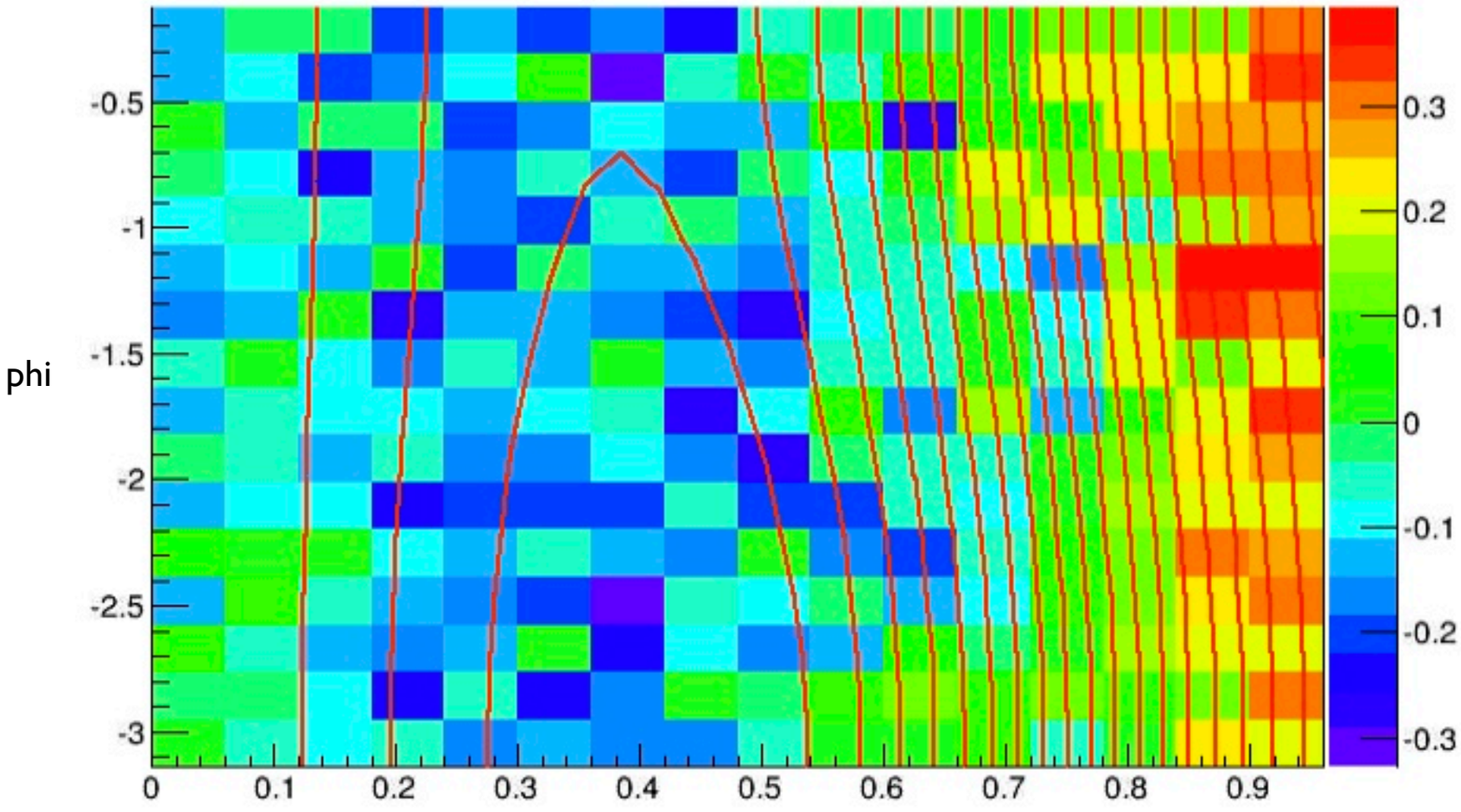
Same exercise for pure longitudinal beam

- First from the theory



Same exercise with both longitudinal and transverse components

- from the simulation ~30,000 x2 events



rho = k'/k'_max

fit parameters:

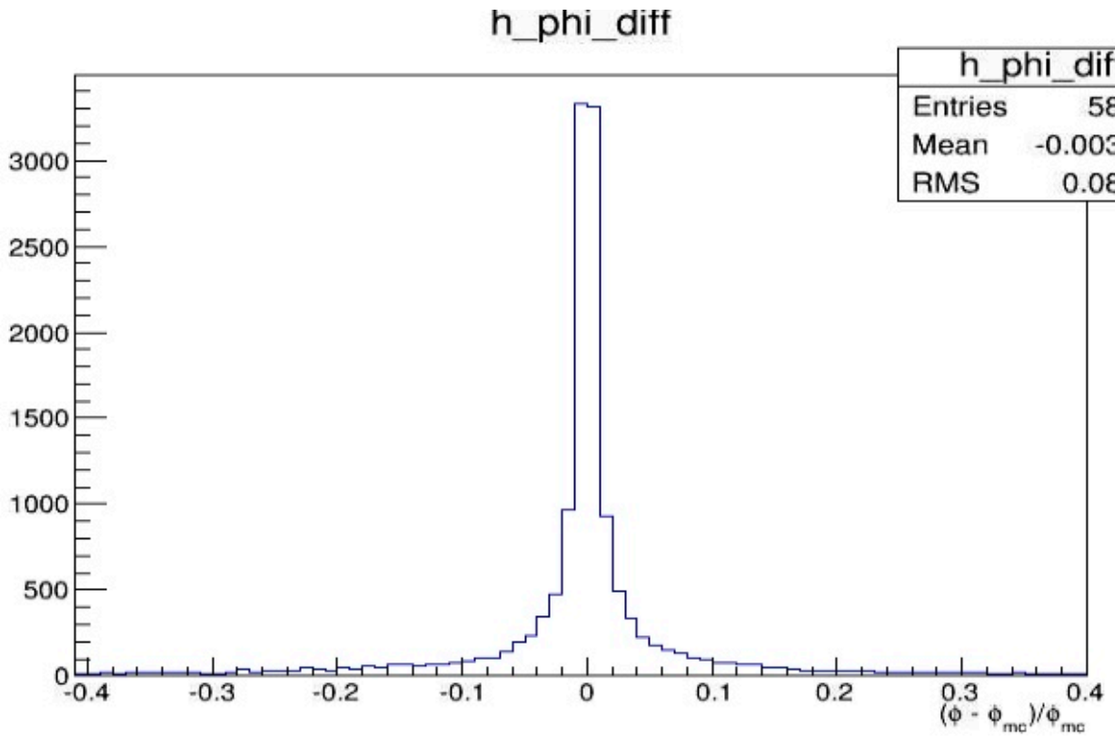
not perfect, but close, generating more stats now

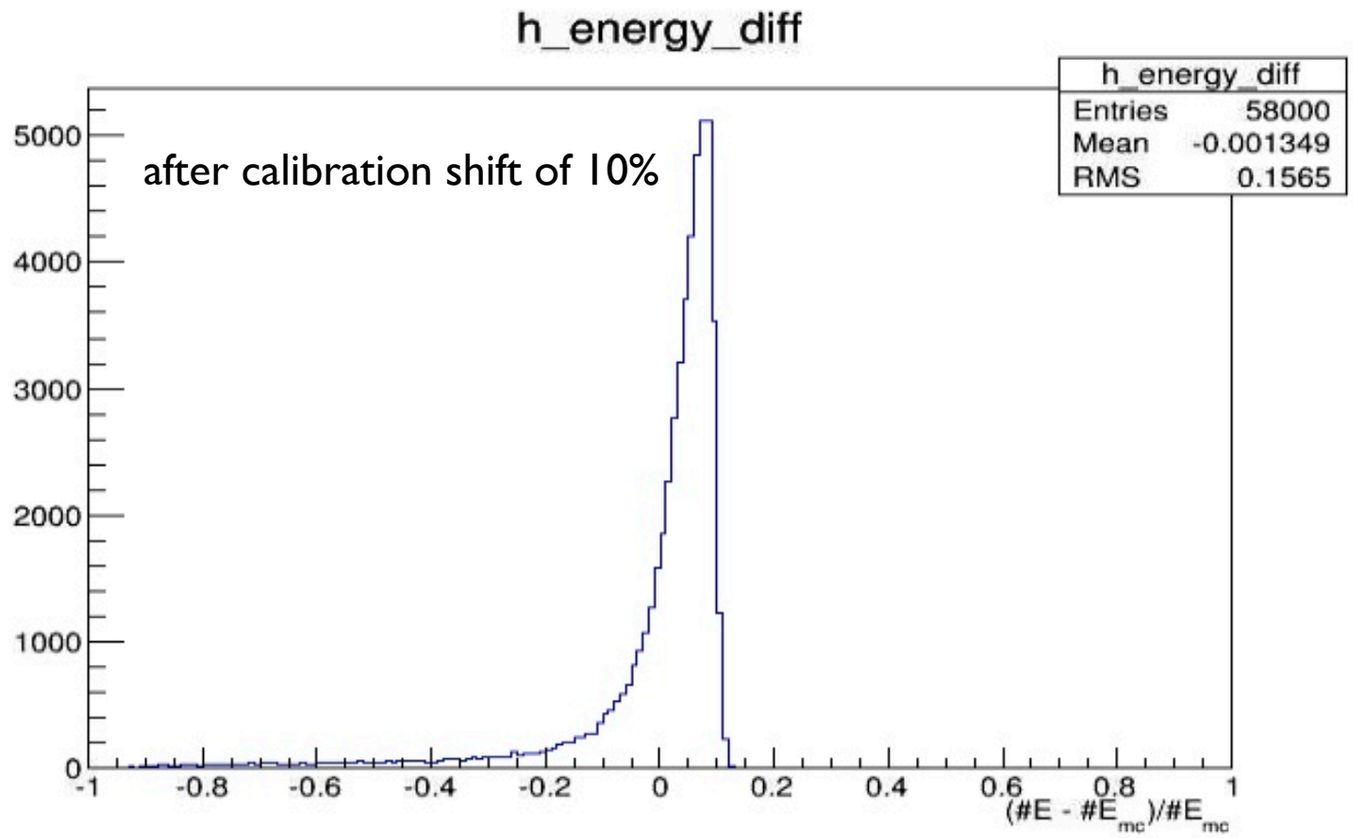
```
FCN=285.396 FROM MIGRAD    STATUS=CONVERGED      41 CALLS          42 TOTAL
                     EDM=1.86314e-10    STRATEGY= 1      ERROR MATRIX ACCURATE
 EXT PARAMETER                                   STEP         FIRST
 NO.   NAME      VALUE            ERROR          SIZE      DERIVATIVE
  1  p0           2.00000e+01     fixed
  2  p1           2.33000e-09     fixed
  3  p2           6.86732e-01   2.88087e-02   2.34124e-04   3.21050e-04
  4  p3           1.46594e-01   6.95179e-02   5.64963e-04   2.20841e-04
```

Fitting on actual simulated data

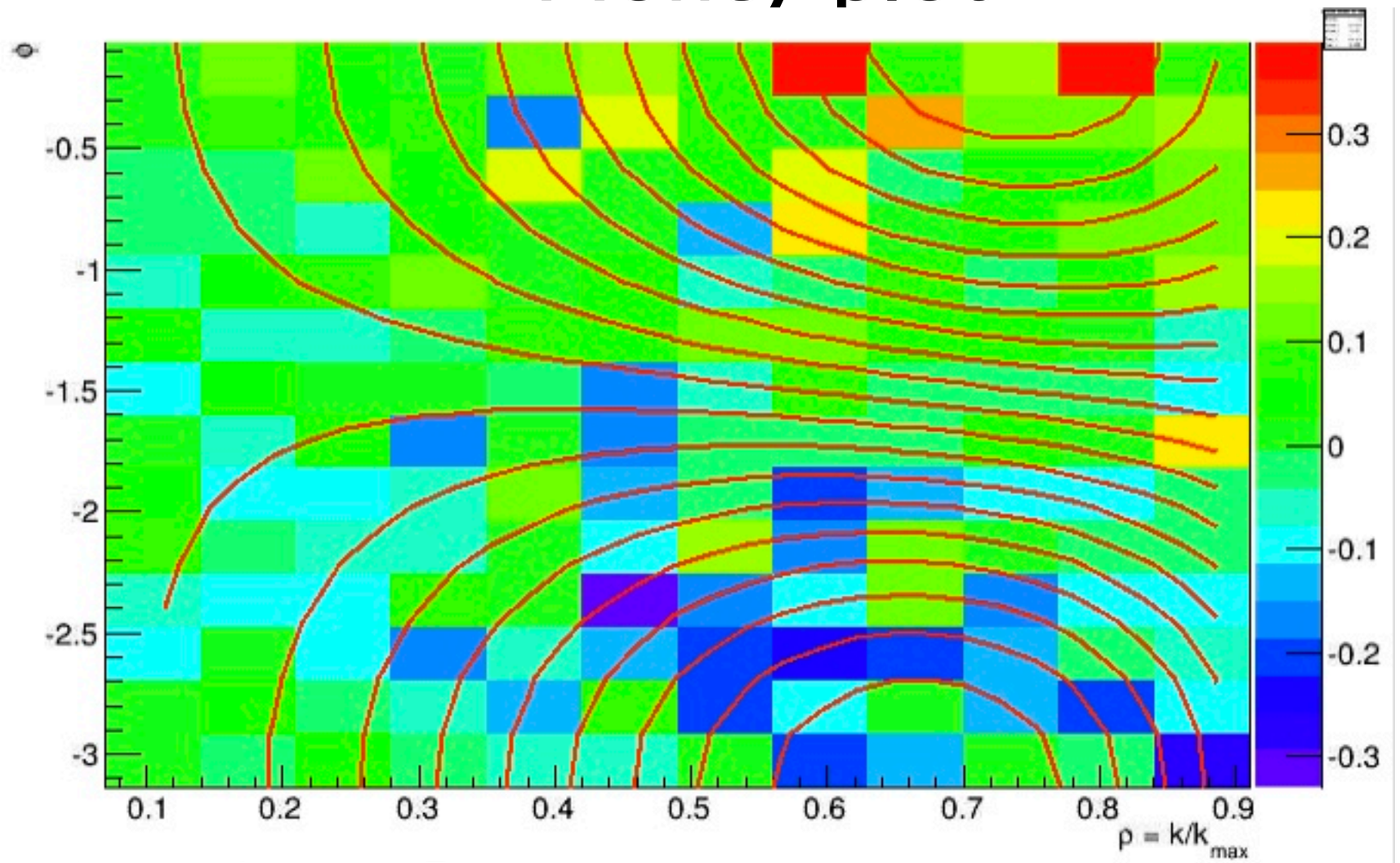
- detector setup details:
  - pre-shower detector consisting of 4 layers of silicon tracker with 2cm thick tungsten in front of each layer
  - tracking layers have pixel size 250x250um
  - followed by calorimeter (2.5cm^2 PbWO towers)
  - set up 100m from the Compton IP
- reconstruction process:
  - start off simple, will currently only work on single particle events
  - tracker --> basically find the center of gravity of hits in all layers in the x-y plane to get a single point of entry of the photon
  - calorimeter --> use the default clusterizer in EicRoot to get cluster energy

Reconstruction performance





Money plot



FCN=159.437 FROM MIGRAD STATUS=CONVERGED 53 CALLS 54 TOTAL
EDM=9.16535e-09 STRATEGY= 1 ERROR MATRIX ACCURATE

EXT NO.	PARAMETER NAME	VALUE	ERROR	STEP SIZE	FIRST DERIVATIVE
1	p0	2.00000e+01	fixed		
2	p1	2.33000e-09	fixed		
3	p2	5.82510e-01	6.09913e-02	3.76360e-04	1.90497e-03
4	p3	1.46214e+00	7.48142e-02	4.62032e-04	-1.03870e-03

- need to generate more statistics, but these seems promising so far

Summary

- new detector design in place
- new simulations underway
- simple tracking algorithm in place
- fitting procedure in place
- in the process of generating more statistics

Clustering algorithm

- EicRoot currently includes a clusterizer for calorimeter hits, but only returns the cluster energy, NOT the position
- now developing the algorithm to determine the position of the cluster along with the energy, which is needed to calculate phi angle
- using the digitized information from EicRoot simulations
- start simple by simply collecting all neighboring towers and doing an energy weighted average to calculate the center of mass of the clusters